ElectroHydroDynamic pattering of Polymers

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Introduction

Electrohydrodynamic instability patterning (EHDIP) is a new MEMS manufacturing process. It uses contoured electrostatic forces at the interface between two polarisable fluids in order to promote a growth in the stronger dielectric material. This material may then be cured to produce 3-D patterns and structures on the micro to meso scale.

This process has the advantage of not requiring any photolithography in order to function. As such it is quicker than conventional processes and also the utilization of hitherto unachievable topographies, including continuous surfaces. Potential applications for this process include:

- Microfluidics (micro channels)
- Microwave technology (interdigitated filters)
- Plastic or polymer electronics (FET)
- Optics (micro lenses, Fourier lenses)

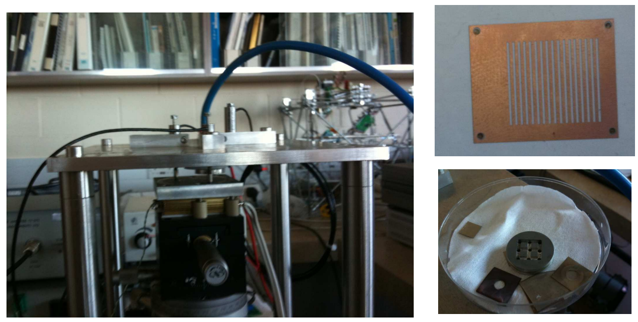


Fig.3: Rig (left) and LCP mask design (top right) and nickel masks (bottom right)

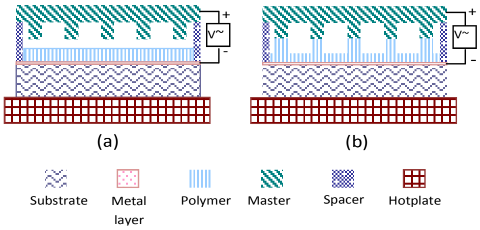


Fig 1 : basic set up of the EHDIP process

Experimental Rig

In order to carry out the experiments necessary, a rig was designed that allows for complete six degrees of freedom of movement, in order to position the mask and polymer. A vacuum chuck built onto supports keeps the masters suspended over the polymer surface. The masters are built from either electroformed nickel or a new novel process using copper clad Liquid Crystal Polymer. A hot plate provides a thermal gradient to help drive the instability as well as curing the polymer if required. Surface Acoustic wave transducers provide a similar function using acoustic pressure to help the process.

Absolute and relative distances are maintained by Linear Variable Differential Transformers (LVDTS) and 3 axis accelerometers configured for static tilt measurements. This gives the gap integrity an accuracy down to nanometre scale. Finally, an inbuilt capacitive sensor provides real time information on the changing volume of the polymer during the process.

Modelling of Electrostatic distribution in polymer

As a first step towards gaining a full appreciation of the mechanism that drives the process, it was desirable to model the electrostatic field distribution as a function of the mask topology in COMSOL multiphysics. Later, a closed form solution for the electrostatic field was calculated using the Schwarz-Christoffel conformal mapping.

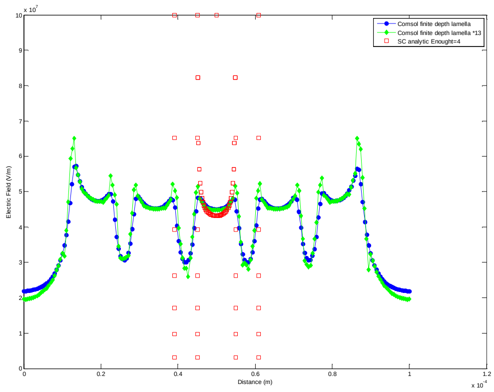
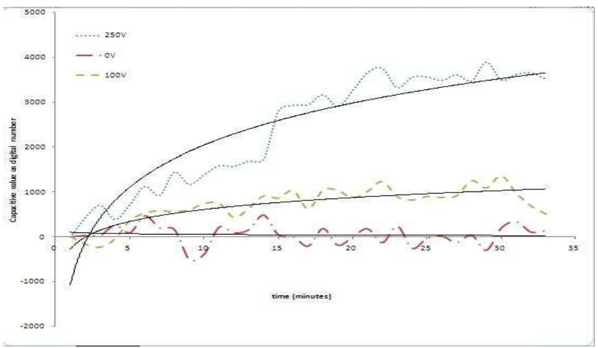


Fig.2. Comparison of COMSOL and Schwarz Christoffel conformal mapping simulation techniques for electrostatic field distribtution



Results

Fig.4: On-line capacitive sensing, showing the rate of change in the polymer volume with respect to time.

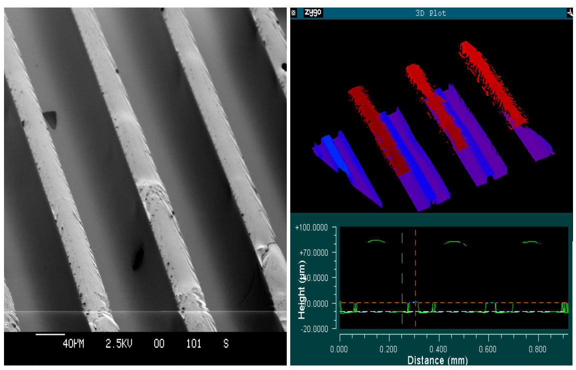


Fig.5: SEM and Zygo profile of microfluidic channels fabricated using EHDIP